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The effects of trauma recall on smoking topography in posttraumatic stress disorder and non-posttraumatic stress disorder trauma survivors

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Abstract

Smoking topography was measured in trauma survivors with and without posttraumatic stress disorder (PTSD) after recalling trauma-related and neutral experiences. Analysis of covariance was performed on puff topography and mood measures using nicotine dependence scores and current major depressive disorder as covariates. Puff volumes were higher in the PTSD group than in the non-PTSD group. The PTSD group exhibited stable puff onset intervals while the non-PTSD group exhibited significantly shorter intervals following trauma recall. These findings support a ''ceiling effect'' hypothesis in which individuals with PTSD perpetually smoke in such a way as to maximize nicotine delivery, possibly reducing the potentially reinforcing effects of increased smoke delivery in negative affect-inducing situations.

Keywords: PTSD; Smoking; Smoking topography; Stress; Anxiety; Trauma

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1. Introduction

Despite representing 22% of the adult U.S. population, individuals with psychiatric conditions consume 44% of all cigarettes sold in the U.S. (Lasser et al., 2000). Given that cigarette smoking costs an estimated 419,000 American lives and US$100 billion in direct and indirect health care expenses annually (CDC, 1994), it is of vital importance to our national health care to learn more about why people with psychiatric conditions smoke at this alarming rate.

Posttraumatic stress disorder (PTSD) is a prevalent psychiatric disorder estimated to occur in 8% (Helzer, Robins, & McEvoy, 1987; Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995) of the U.S. population and is chronic in a third of sufferers. Fifty-three percent to 60% of individuals with PTSD smoke (Beckham, 1999) and they are more likely to be heavy smokers (48% compared with 28% in non-PTSD smokers; Beckham et al., 1997). When individuals with PTSD were exposed to trauma-related stimuli using a modified Stroop procedure, they experienced increased smoking craving compared with those without PTSD (Beckham et al., 1996). These results suggest that trauma-related stimuli may serve as a compelling cue for smoking in individuals with trauma exposure or PTSD. Whether trauma stimuli affect smoking behavior has not yet been examined.

Smokers report anxiety reduction as a motivation to smoke (Brandon, 1994) and there is a growing body of literature examining the relationship among nicotine, smoking, and stress/negative affect (for reviews, see Gilbert, 1995; Kassel, Stroud, & Paronis, 2003). Controlling for smoker expectancies about cigarette nicotine content, smoking nicotine-containing cigarettes after anxiety induction produced greater relief from anxiety than denicotinized cigarettes (Juliano & Brandon, 2002). Kassel and Unrod (2000) observed reductions in anxiety in subjects smoking cigarettes during anxiety induction, but only when a distracting stimulus was present. Relatively fewer laboratory studies have assessed the effects of stress and negative affect on smoke self-administration using smoking topography methods.

Smoking topography methodology is a valuable tool for assessing the effects of subject (e.g., Eissenberg, Adams, Riggins, & Likness, 1999) and experimental manipulations (e.g., Cohen, Britt, Collins, Stott, & Carter, 1999; Palfai, Colby, Monti, & Rohsenow, 1997) on cigarette smoke self-administration. Studies where stress/anxiety are induced have typically observed changes in smoking behavior consistent with increased smoke administration. Using a learned helplessness paradigm, Payne, Schare, Levis, and Colletti (1991) observed greater number of puffs and total puff duration following negative affect induction. Similarly, Rose, Ananda, and Jarvik (1983) found greater puff volumes and increased puff frequencies in two tension-inducing conditions compared with a relaxation condition.

Based on previous work suggesting that trauma reminders affect smoking craving (Beckham et al., 1996), we hypothesized that recalling traumatic versus neutral experiences would result in smoking behavior indicative of increased smoke intake following trauma recall versus a neutral condition. Further, we hypothesized that smoking intake would be significantly greater in the PTSD group following trauma recall.

2. Method

2.1. Participants

The sample of 110 smokers consisted of 74 individuals diagnosed with PTSD and 36 individuals with trauma history but without PTSD based on the clinician-administered PTSD scale (Blake et al., 1995). This sample was part of a larger study examining mood and smoking in PTSD patients (Beckham et al., 2004). Inclusion criteria were 18 years of age, a smoking history of >10 cigarettes per day for the past year, and at least one lifetime trauma exposure. The Structured Interview for DSM-IV Diagnosis (SCID; First, Spitzer, Gibbon, & Williams, 1994) was administered to assess Axis I disorders. Candidates who met DSM-IV criteria for organic mental disorder, schizophrenia, current manic syndrome, current substance abuse/dependence, or lifetime but not current PTSD were excluded. Participants with contraindicated medical diagnoses were excluded. Of the 222 participants who were screened for the study, 71 were excluded for the following: lifetime but not current PTSD ($n=21$), drug and alcohol dependence ($n=15$), contra-indicated medical condition ($n=3$), psychiatric condition ($n=15$), active suicidality ($n=1$), and other exclusion criteria (such as not smoking enough; $n=16$). Of the 151 enrolled, 14 never returned for study sessions. An additional 27 participants had incomplete or missing smoking topography data. One hundred ten smokers were included in this analysis (see Table 1 for participant characteristics). Smokers were paid US$150 for their participation.

2.2. Procedure

Participants completed two sessions—a screening session in which background information was obtained and a script development/trauma recall session. Trauma recall was completed using a script development procedure outlined by Pitman's research group (Orr, Pitman, Lasko, & Herz, 1993; Pitman et al., 1990). Two individualized scripts portraying actual experiences from the participant's past were composed, including a personal traumatic event and a neutral experience. All participants were first asked to describe each experience in writing on a script preparation form, and then to select from a "menu" of subjective visceral and muscular reactions s/he remembered occurring during the experience. Participants smoked a cigarette of their usual brand after writing about each experience through a smoke-delivery apparatus (described below) designed to measure puff topography.

Smoking topography was measured using a smoke-delivery apparatus validated in previous studies (Levin, Rose, & Behm, 1989). When employed to measure (as opposed to controlling) puff volume, a large glass syringe is initially filled with 80 cc prior to each puff, and the reading after each puff indicates the volume drawn into the mouth. The number of puffs, puff volume, and puff onset interval were recorded. In a previous study of nicotine administration, participants reported substantial smoking satisfaction after taking puffs through the apparatus (Rose et al., 1994).

Table 1
Demographic and psychiatric information by group

Variable	Total ($N=110$)	PTSD ($n=74$)	Non-PTSD ($n=36$)
Male	58 (52.7%)	37 (50%)	21 (58.3%)
Nonveteran	48 (43.6%)	31 (41.9%)	17 (47.2%)
Age	44.62 (11.21)	44.64 (11.23)	44.58 (11.31)
Education*	13.50 (2.11)	13.14 (2.08)	14.22 (2.02)
Race			
Caucasian	38 (34.5%)	23 (31.1%)	15 (41.7%)
African-American	67 (60.9%)	47 (63.5%)	20 (55.6%)
Indian	1 (.9%)	1 (1.4%)	0 (0%)
Other	4 (3.6%)	3 (4.1%)	1 (2.8%)
DTS			
B score*	14.17 (11.10)	18.20 (10.54)	5.89 (6.86)
C score*	22.09 (16.37)	26.81 (15.08)	12.39 (14.70)
D score*	18.94 (12.42)	23.28 (10.63)	10.00 (11.06)
Total score*	55.13 (37.19)	68.19 (33.30)	28.28 (29.86)
Smoking variables			
Cigarettes per day	22.97 (10.18)	24.12 (10.34)	21.67 (9.52)
Age started smoking	16.19 (4.64)	16.03 (4.66)	16.53 (4.66)
Total years smoked	27.25 (12.76)	27.45 (12.71)	26.86 (13.04)
Times tried to quit	3.37 (3.38)	3.71 (3.29)	2.69 (3.50)
Number of times quit	.64 (1.02)	.74 (1.15)	.43 (.65)
Pack years	33.31 (24.56)	35.41 (25.79)	29.00 (21.52)
FTND score*	6.48 (2.22)	7.07 (1.78)	5.28 (2.56)
CO level	27.63 (12.59)	27.39 (13.24)	28.20 (12.59)
SCID			
Major depressive, current*	32 (29.1%)	30 (40.5%)	2 (5.6%)
Major depressive, lifetime*	73 (66.4%)	60 (81.1%)	13 (36.1%)
Comorbid anxiety, current*	43 (39.4%)	39 (53.4%)	4 (11.1%)
Comorbid anxiety, lifetime*	54 (50%)	47 (65.3%)	7 (19.4%)
Substance abuse, lifetime*	74 (67.3%)	57 (77.0%)	17 (47.2%)
Medications			
Antihypertensive	32 (28.8%)	21 (30.6%)	11 (29.4%)
Beta-blocker	12 (11.0%)	8 (11.0%)	4 (11.1%)
Alpha-adrenergic*	21 (19.3%)	19 (26.0%)	2 (5.6%)
Anticholinergic	7 (6.4%)	6 (8.2%)	1 (2.8%)
Any medication	82 (75.2%)	60 (82.2%)	22 (61.1%)

PTSD and non-PTSD group differed significantly (as indicated by asterisks) on years of education [$t(108)=-2.59$, $P<.05$], DTS B, C, D, and DTS total scores (all P's $<.001$), current major depression ($\chi^2=14.37$, $P<.001$), lifetime major depressive disorder ($\chi^2=21.94$, $P<.001$), current comorbid anxiety disorder ($\chi^2=18.07$, $P<.001$), lifetime comorbid anxiety disorder ($\chi^2=20.17$, $P<.001$), lifetime substance abuse or dependence ($\chi^2=9.77$, $P<.01$), and alpha-adrenergic drug use ($\chi^2=6.50$, $P<.05$).

2.3. Symptom measures

The 10-item Questionnaire on Smoking Urges (QSU; Tiffany & Drobes, 1991) has been shown to have highly reliable factors: .95 for Factor 1 and .93 for Factor 2. Factor 1 reflects anticipation of pleasure from smoking. Factor 2 reflects anticipation of relief from negative affect.

The 20-item Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) consists of 10 positive (e.g., alert) and 10 negative (e.g., distressed) adjectives. Items are rated on a five-point Likert scale and summed by affect category to form Positive Affect and Negative Affect scales.

The Davidson Trauma Scale (DTS; Davidson et al., 1997) is a self-report measure that assesses the frequency and severity of PTSD symptoms. In the state version used in the present study, respondents rated the frequency and severity of PTSD criteria B, C, and D symptoms within the past 10 min. Frequency ratings range from 0 (*not at all*) to 4 (*more than six times*) and severity ratings range from 0 (*not at all distressing*) to 4 (*extremely distressing*). Responses were scored as a total and separate B, C, and D symptom scores. The DTS has high reliability and validity (Davidson et al., 1997).

2.4. Data analyses

All dependent variables were submitted to 2 (PTSD group: PTSD, non-PTSD) × 2 (Sex: men, women) × 2 (Recall Condition: neutral, trauma) repeated measures analysis of covariance. Baseline Fagerström Test for Nicotine Dependence scores and current major depressive disorder served as covariates. Differences in df denominators reflect that the PANAS was added during the course of the study.

3. Results

3.1. Smoking topography

3.1.1. Mean puff volume

As shown in Fig. 1, larger mean puff volumes were observed in the PTSD group (adjusted mean = 35.41 ml) than in the non-PTSD group (adjusted mean = 29.95 ml), [$F(1,103) = 4.32$, $P = .040$]. Additionally, mean puff volumes were larger in men (adjusted mean = 36.10 ml) compared with women (adjusted mean = 29.27 ml) [$F(1,103) = 8.49$, $P = .004$].

3.1.2. Mean puff onset interval

As shown in Fig. 1, a Recall Condition × PTSD group interaction was observed for the log of mean puff onset interval [$F(1,103) = 7.00$, $P = .009$]. Post hoc tests indicated that in the non-PTSD group, intervals were significantly ($P < .01$) shorter following traumatic relative to neutral event recall (adjusted means = 29.11 and 37.96 s, respectively). No differences between the trauma and neutral conditions were observed in the PTSD group (adjusted means = 34.01 and 35.86 s, respectively).

3.1.3. Number of puffs

A Recall Condition × Sex interaction was observed for number of puffs [$F(1,103) = 4.15$, $P = .044$]. However, post hoc tests did not indicate significant differences.

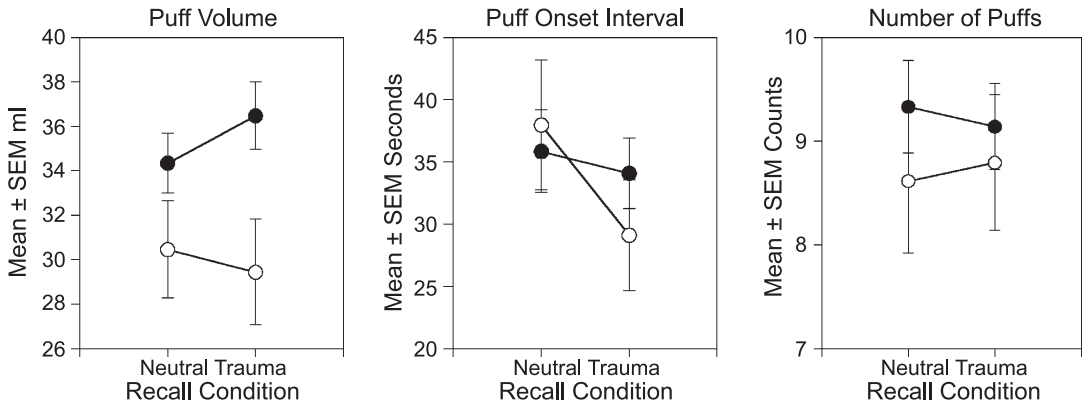

Fig. 1. Adjusted mean (± S.E.M.) puff volume, puff onset interval, and number of puffs following neutral and trauma recall in trauma survivors with (●) and without (○) PTSD.

3.2. Self-report

3.2.1. Craving

No significant effects were observed for the QSU scale or total scores.

3.2.2. PTSD symptoms

The PTSD group exhibited higher DTS (last 10 min) B, C, D, and total scores [F's(1,101) = 11.26–19.31, P's < .002] compared with the non-PTSD group.

Interactions between PTSD group and recall condition were observed for DTS B, C, and D scales and DTS total score [F's(1,101) = 4.02–6.46, P's < .05] (see Fig. 2). Post hoc analyses indicated that for both groups, DTS B, C, and total scores were significantly (all P's < .05) higher following trauma recall compared with neutral event recall. For DTS D, only the PTSD group exhibited significantly higher scores in the trauma condition. For all measures, the PTSD group exhibited significantly (all P's < .05) higher scores than the non-PTSD group following trauma recall.

Main effects of sex were observed for DTS B, C, D, and total scores [F's(1,101) = 12.66–23.46, P's < .002]. For all measures, men exhibited higher DTS scores compared with women.

Recall Condition × Sex interactions were found for DTS B [$F(1,101) = 17.57$, $P < .001$] and total scores [$F(1,101) = 6.66$, $P = .011$]. Post hoc analyses of both variables indicated that men had significantly (P's < .001) higher scores than women in the neutral, but not trauma recall condition. This is consistent with higher baseline DTS scores in men.

3.2.3. Positive and negative affect

A main effect of PTSD group [$F(1,80) = 5.64$, $P = .02$] and a PTSD Group × Recall Condition interaction [$F(1,80) = 5.63$, $P = .020$] were observed for PANAS negative affect scores (see Fig. 2). Negative affect scores were higher in the PTSD group compared with the

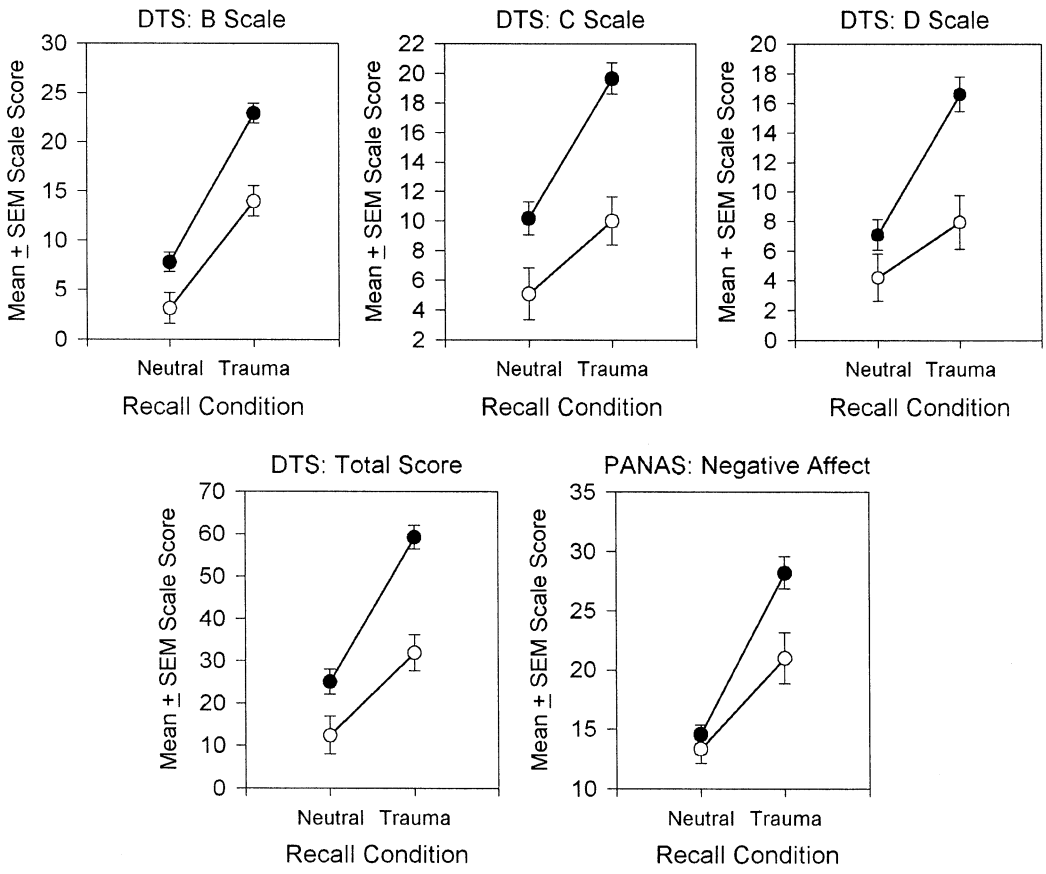

Fig. 2. Adjusted mean (± S.E.M.) scale scores for DTS B, C, D, and total scores and PANAS negative affect following neutral and trauma recall in trauma survivors with (●) and without (○) PTSD.

non-PTSD group. Post hoc analyses revealed that negative affect scores were significantly higher in both groups (P's < .001) in the trauma recall compared with the neutral condition. In the trauma recall condition, but not in the neutral condition, negative affect scores were significantly (P < .01) higher in the PTSD group.

A Recall Condition × Sex interaction was observed for PANAS positive affect scale scores [$F(1,80) = 4.24$, P=.043]. Post hoc tests revealed that women reported significantly (P < .001) higher positive affect in the neutral as compared with trauma condition. Further, following trauma recall, women reported significantly (P < .05) lower levels of positive affect compared with men.

A main effect of PTSD group [$F(1,80) = 5.64$, P=.02] and a PTSD Group × Recall Condition interaction [$F(1,80) = 5.63$, P=.020] were observed for PANAS negative affect scores. Negative affect scores were higher in the PTSD group compared with the non-PTSD group. Post hoc analyses revealed that negative affect scores were significantly lower in both groups (P's < .001) in the neutral compared with trauma recall conditions. In the trauma recall

condition, negative affect scores were significantly ($P < .01$) higher in the PTSD group than in the non-PTSD group.

4. Discussion

The present study partially supported the initial hypotheses. As expected, smokers with PTSD reported significantly higher negative affect and PTSD symptoms following trauma recall compared with a neutral recall condition. Controlling for nicotine dependence and the presence of current major depressive disorder, the non-PTSD group took less time between puffs in response to trauma recall compared with neutral recall. However, in the PTSD group, rather than differentially responding to the trauma recall condition, participants with PTSD smoked in such a way as to maximize smoke delivery as evidenced by higher puff volumes across conditions.

The higher puff volume observed in the PTSD group is consistent with previous research indicating this patient population may smoke in such a way as to deliver higher nicotine levels (Beckham et al., 1997). Indeed, in an ambulatory study we showed that individuals with PTSD smoke more cigarettes per day and at a higher frequency than individuals without PTSD (Beckham et al., 2004). Interestingly, in the present study, higher baseline CO levels were not observed in the PTSD group as might be expected given their larger puff volumes. However, CO was typically assessed between 8 and 10 a.m. Thus, CO levels in the PTSD and non-PTSD groups could conceivably diverge over the course of the day. Further, previous smoking topography studies have not demonstrated reliable, positive relationships between puff volume and CO levels (Eissenberg et al., 1999).

Puff volume and number of puffs taken were unaffected by recall of trauma information in both groups. Puff onset interval, however, was modified by the recall of a traumatic experience, but only in non-PTSD trauma survivors. In this group, trauma recall was associated with significantly shorter intervals between puffs compared with neutral experience recall. Such decreases in puff onset intervals would not necessarily result in an overall increase in nicotine delivery if puff volume or number of puffs remained the same (which they did) but would decrease the time required to achieve optimal blood nicotine levels. If these individuals were smoking to decrease negative affect or PTSD symptoms associated with trauma recall, achieving optimal blood nicotine levels sooner would thus presumably result in quicker relief from these symptoms. Consistent with decreases in puff interval, although these smokers were not diagnosed with PTSD, they reported increased PTSD symptoms and negative affect following trauma recall as compared with neutral experience recall.

These findings for the non-PTSD group are consistent with previous studies, which have observed changes in smoking topography indicative of increased smoke delivery following stressful, negative affect inducing situations (Payne et al., 1991; Rose et al., 1983). While these and the present findings for the non-PTSD group all produced different patterns of smoking topography, all were indicative of increased smoke delivery in the face of stress inducing situations. Differences in studies, thus, may be due to the specific methods used to

measure smoking topography: the type, duration, and intensity of negative affect induction employed and other methodological differences (e.g., cigarette smoked during or after the stressful situation).

Unexpectedly and in contrast to the non-PTSD group and to the literature, mean puff onset interval did not decrease in the PTSD group in response to trauma recall. Given that our other measures of smoking topography—number of puffs and puff volume—were also unaltered by trauma recall, these results suggest that individuals with PTSD may not adjust their smoking behavior across laboratory neutral versus trauma recall situations, even when recall significantly increases PTSD symptoms and negative affect. Thus, while mood and PTSD symptoms were negatively affected by trauma recall in smokers with PTSD, their smoking behavior was not.

The above findings partially support Gilbert's situation × trait-adaptive response (STAR) model of smoking motivation (Gilbert, 1995), which would hypothesize that smokers with PTSD would (1) smoke at a greater rate to self-medicate higher baseline levels of anxiety and (2) increase nicotine intake in response to trauma-related stimuli. In support of the first hypothesis, smokers with PTSD in our study exhibited higher puff volumes than their non-PTSD counterparts.

Contrary to the second hypothesis, however, compared with non-PTSD smokers, changes in smoking behavior were not observed in the PTSD group following trauma recall. The stable responding observed in the PTSD group may be due, in part, to their higher baseline levels of smoke intake (i.e., higher puff volumes), which might make shorter interpuff intervals less reinforcing. Thus, a ceiling effect in the reinforcing effects of nicotine may explain why the PTSD group would exhibit stable smoking behavior in response to trauma recall while still experiencing increased PTSD symptoms and negative affect.

Inconsistent with a previous study in our laboratory, in which trauma-related words presented in a Stroop task paradigm induced craving (Beckham et al., 1996), self-report craving was not significantly higher in response to trauma recall in the present study. However, the size of the effect observed in the previous study was modest and other methodological factors may account for this difference.

The only observed sex difference in laboratory smoking was that compared with men, women had lower puff volumes; which is consistent with Eissenberg et al.'s (1999) findings that women take smaller and shorter puffs than men.

The present study is limited by several factors. First, while we measured puff topography, measurement of plasma nicotine, and expired CO levels following each smoking period would have provided additional information regarding the effects of trauma recall on smoking behavior. Second, participants smoked and made ratings after trauma and neutral recall conditions. Thus, our findings may be due to increases in arousal associated with recall of negative affect-inducing material not specific to trauma experience recall. Third, these results can only be generalized to trauma-exposed smokers with and without PTSD and not to smokers with no previous trauma exposure. However, since 70% of individuals are exposed to at least one trauma during their lifespan (Kessler et al., 1995), the results would generalize to the majority of smokers.

Nonetheless, the results of the current study are the first report that smoking topography may significantly vary by psychiatric condition (i.e., that smokers with PTSD demonstrate higher puff volumes). Further, results of the current study are the first to suggest that recall of emotionally significant material can affect smoking topography differentially across subtypes of smokers (e.g., those with PTSD vs. those without PTSD).

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